

**CONSERVATION OF 19TH AND EARLY 20TH  
CENTURY OIL PAINTINGS: STUDIES OF  
PIGMENT DISCOLOURATION BY SCANNING  
ELECTRON MICROSCOPY**

By

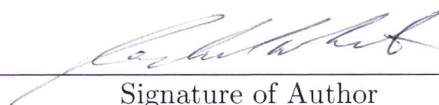
Rachel Elizabeth White

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## Certificate

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*For Lawson*

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# Nomenclature

Table 1: List of symbols and abbreviations

amu	atomic mass units
BSE	backscattered electrons
DTG	Differential Thermogravimetric Analyses
$E_0$	Electron beam energy
ESEM	Environmental Scanning Electron Microscope
nA	nanoamps
nm	nanometre
SEM	Scanning Electron Microscope
T	Torr
TG	Thermogravimetric Analyses
WOF	width of field
XRD	X-ray Diffraction



# Abstract

The discolouration of artistic oil paintings due to pigment interaction has been a concern for artists and painting conservators since the early 1800s. Since then there has been considerable speculation on the origin and mode of this discolouration. This project sought to determine what discolouring interactions between pigments exist in historic oil paintings and to understand the mechanisms involved. The discolouring pigment system was studied using x-ray diffraction, thermal analysis, x-ray microanalysis techniques and hydration experiments using an Environmental Scanning Electron Microscope.

A discolouring chemical interaction between cadmium yellow (a cadmium sulfide pigment) and malachite (basic copper carbonate) was identified. The darkening reaction between copper containing pigments and the range of cadmium sulfide pigments was established to be the only discolouring that occurs between artistic pigments investigated in this work. This interaction occurs due to copper ions being mobile in the drying oils used for oil painting. The copper ions are taken up by the oil medium and transported throughout the oil layer to adjoining paint layers. Any cadmium sulfide present in the oil painting will undergo ion exchange at its surface with the copper ions in the medium to produce copper sulfide. The copper-cadmium ion exchange was found to continue until the cadmium sulfide is completely converted to copper sulfide. For the combination of cadmium yellow and malachite it was established that the discolouring copper sulfide was covellite, CuS.

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